

10 ENGINES

Power Generation and Propulsion,
Electrical Vehicles**99/03328 Study on behavior of minerals in coal in combustion furnace**

Xiang, C. and Li, F. *Wuhan Gongye Daxue Xuebao*, 1998, 20, (2), 17-19. (In Chinese)

A study was carried out on the variations of components and mineral content in coal during heating at 800-1400°C in a muffle furnace and a quadrangular combustion furnace using X-ray diffraction. The results showed that the behaviour of coal ash in a combustion furnace was similar to that in a muffle furnace and has a strong relationship to the compositions of raw coal.

99/03329 Study on calcium sulfide: formation and sulfur capture efficiency during coal briquet combustion

Lu, X. *et al.* *Huanjing Huaxue*, 1998, 17, (6), 528-531. (In Chinese)

Sulfur capture using calcium-based absorber and an additive (iron, silicon), was studied in two groups of experiments. In the first group, the coal was heated continuously from room temperature to the designated one and another sample was heated from room temperature again. In the second the coal was burned quickly. The residues were analysed with XRFA and XRPD. High efficiency of sulfur retention at high temperature (1300°C) were obtained from the second group of experiments with calcium sulfide formed by large magnitude. The mechanism of sulfur retention is explained through identification of vitreous iron oxides and small amounts of silicate.

99/03330 Study on trace metal partitioning in pulverized combustion of bituminous coal and dry sewage sludge

Cenni, R. *et al.* *Waste Mgt*, 1998, 18, (6-8), 433-444.

A study of the influence of co-firing of dry municipal sewage sludge on the behaviour of the metals chromium, mercury, manganese, nickel, lead and zinc during pulverized coal combustion is presented. Sewage sludge contains higher concentrations of the metals listed above than the reference coal, but a lower concentration of chlorine, that enhances the volatility of many metals. Experiments were performed in a semi-industrial scale pulverized fuel combustion chamber (500 kW). Ash was collected at four locations: bottom hopper ($T = 850$ K), air preheater ($T = 750$ K), cyclone ($T = 620$ K) and bag filter ($T = 480$ K). From the bottom hopper to the filter, the particle size decreased and ash particles were progressively enriched in volatile elements. Mass balances of the metals were performed and the enrichment trends on the ash collected at the different locations were calculated. Increasing the sewage sludge share in the blend caused a significant increase in the recovery rate in the solid phase. In spite of that, the calculated concentrations in the flue gas of mercury and zinc increased. Sewage sludge co-firing influences the combustion process and the post-combustion environment in many ways. This study focuses on the effect of the different flue gas compositions on the condensation temperature of metal species. The system was modelled by assuming thermodynamic equilibrium. The results indicated that the increasing recovery of zinc might be caused by enhanced condensation and the increasing recovery of mercury by adsorption on ash particles. The increasing recovery of the other metals seemed referable to failure in vaporization and it cannot be studied with an equilibrium approach.

99/03331 Understanding of the mechanisms of the combustion of char and volatiles with regard to their contribution to the levels of NO_x and N_2O formed in both atmospheric and pressurised fluidised bed combustors

Boavida, I. and Gulyurtlu, D. *Eur. Comm., [Rep.] EUR*, 1998, (EUR 17933), 1-48.

With the objective of a more comprehensive understanding of the complexity of the interaction between reactions and fluid dynamics occurring in various types of fluidized bed combustors during the combustion of coals, this work aimed to minimize the levels of NO_x and N_2O formed. Studies were undertaken both at INETI and the University of Delft with regard to the formation of N_2O and NO_x during the fluidized bed combustion of coals. The nature of nitrogenous compounds present in parent coal and the temperature of devolatilization have an important influence on the amount of both N_2O and NO formed. The main source of both N_2O and NO is the combustion of char; however, the volatiles significantly contribute to the amount of N_2O formed. Char also appears to give rise to a considerable reduction of both N_2O and NO during combustion. The presence of volatiles very close to the char particle surface could lead to the suppression of oxidation reactions in the gas phase, thus giving rise to a reduction in the total amount of N_2O and NO formed. It is difficult to establish a link between the functional forms of nitrogen in coals and the formation of HCN and NH_3 at the various stages of devolatilization, but it is believed that the nature of nitrogen linkage to coal structure is very influential on the extension of the retention of nitrogen-coal in chars. The nature of nitrogenous compounds present in the parent coal and the temperature of devolatilization have an important influence on the amount of both N_2O and NO formed.

99/03332 Analysis of an irreversible Ericsson engine with a realistic regenerator

Berrin Erbay, L. and Yavuz, H. *Applied Energy*, 1999, 62, (3), 155-167. Fitted with a realistic regenerator, an internally irreversible Ericsson engine has been analysed. The study considers internal irreversibilities with the introduction of turbine and compressor thermal-efficiencies and pressure-drops present in realistic regenerators. The effects of internal irreversibilities on the power output and thermal efficiency of the cycle have been determined using the finite-time thermodynamics. Maximum power-density, rather than maximum power, was used as the criterion for optimization, with the objective of having a more efficient small-sized engine.

99/03333 CHP-expanding plant options to increase its take-up

Peacock, N. *Energy World*, March 1999, 267, 16-17.

The author looks at recent development of 'micro turbines' and its implication for combined heat and power technology, detailing the latest news in the technology and giving advice for the future.

99/03334 Coal conversion. Development of an LCV gas combustor with very low fuel nitrogen oxidation for gas turbines

British Coal Corporation *Eur. Comm., [Rep.] EUR*, 1998, (EUR 17927), 1-49.

Gas turbines which can effectively use the low CV fuel gas produced during coal gasification are needed in the air blown gasification cycle (ABGC) and other similar coal-burning power generation cycles. Previous work has developed the combustion technology to burn low CV fuel-gas satisfactorily with only minor modifications to existing industrial gas turbine hardware. However, combustion systems based on existing combustor design principles were only moderately effective at controlling the emissions of nitrogen oxides (NO_x) resulting from fuel-bound nitrogen. The project aimed to develop advanced low- NO_x combustors and to test them at approximately half full-scale. An integrated development programme, using a laboratory-scale pressurized flame test rig, mathematical modelling techniques and prototype combustor testing on real and synthetic fuel-gas was adopted. The test work on combustor variants 6-10 and the Flame Rig showed that: (1) combustors with richer primary zone produce less NO_x ; (2) CH_4 concentration within the range 1-5% had no effect on NO_x formation, although earlier work had shown that less NO_x was produced with fuel-gases containing no CH_4 ; (3) there is a limit to the effective length of the primary combustion zone; (4) increased combustor pressure.

99/03335 Effects of spray characteristics on combustion performance of a liquid fuel spray in a gas turbine combustor

Datta, A. and Som, S. K. *Int. J. Energy Res.*, 1999, 23, (3), 217-228.

An important role is played by spray characteristics like mean drop diameter and spray cone angle in the process of combustion within a gas turbine combustor. In order to study their effects on wall and exit temperature distributions and combustion efficiency in the combustor, a numerical model of a typical diffusion controlled spray combustion in a can-type gas turbine combustion chamber has been derived. A simple $k-\epsilon$ model with wall function treatment for near-wall region has been adopted for the solution of conservation equations in carrier phase. The initial spray parameters are specified by a suitable PDF for size distribution and a given spray cone angle. A radiation model for the gas phase, based on modified first order moment method and in consideration of the gas phase as a grey absorbing-emitting medium, has been adopted in the analysis.

99/03336 Electric co-generation units equipped with wood gasifier and Stirling engine

Bartolini, C. M. *et al.* *Proc. Intersoc. Energy Convers. Eng. Conf., [computer optical disk]*, 1998, 33, IECEC219/1-5.

Due to the increasing problem of the disposal of industrial waste such as oil sludges, waste plastic, lubricant oils, paper and wood, interest in energy recovery technologies is on the increase. In particular, large amounts of waste wood are simply burned or thrown away causing considerable environmental damage. The co-generation technique represents one of the possible solutions for efficient energy conversion. The employment of a Stirling engine as prime mover in a co-generation set equipped with a wood gasifier is proposed in this paper. More specifically a Stirling engine prototype previously developed in a joint project with Mase Generators, an Italian manufacturer of fixed and portable electrogenerators, is illustrated and its design is described.